19. MARINE AND ESTUARINE ECOLOGY

This chapter describes the marine and estuarine ecology values within and surrounding the project area (Port Curtis), assesses the potential impacts of the project on these values and describes the measures Arrow Energy will implement through project design, construction and operations to manage impacts on these values.

This chapter is based on the marine and estuarine ecology impact assessment completed by Coffey Environments and supplemented by targeted field investigations completed by Central Queensland University (Appendix 12, Marine and Estuarine Ecology Impact Assessment).

The objectives for marine and estuarine ecology have been developed based on the relevant legislative context with the aim of protecting the existing values. The objectives are set out in Box 19.1.

Box 19.1 Objectives: Marine and estuarine ecology

- To avoid or reduce potential adverse effects resulting from the project on marine and estuarine ecology, including benthic habitats, pelagic species and migratory cetaceans and marine turtles.
- To prevent the introduction and spread of marine pest species.

19.1 Legislative Context and Standards

This section outlines the specific legislation and policies that are enforced to protect the values of both the marine and estuarine environment within and surrounding the study area. Internationally protected areas are described that may be affected (either negatively or positively) by the construction, operation and decommissioning of the project.

19.1.1 Commonwealth Legislation

The following Commonwealth legislation is relevant to the protection of marine and estuarine environmental values:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act). This act provides for the protection of matters of national environmental significance, including listed threatened species and ecosystems, listed migratory species and protected areas. The development proposal has been declared a controlled action under the EPBC Act, and the EIS must address potential impacts on matters of national environmental significance identified under the EPBC referrals for the project (EPBC 2009/5007 and EPBC 2009/5008). Protected matters covered by the EPBC Act relevant to the project include:
  - Commonwealth marine areas.
  - Listed threatened species.
  - Listed migratory species.
  - Listed marine species.
  - World Heritage areas.
  - Wetlands of international importance (e.g., Ramsar wetlands).
- *Great Barrier Reef Marine Park Act 1975.* This act is the predominant legislative measure to promote and enforce the long-term protection and conservation of environmental, biodiversity and heritage values of the Great Barrier Reef region. The act provides for implementation of a

management framework for the ecologically sustainable use of the Great Barrier Reef region, while aiding Australia's international responsibilities to World Heritage and the environment.

Although the project infrastructure is not located within the boundaries of the Great Barrier Reef Marine Park (GBRMP), LNG carriers will traverse the marine park (see Figure 1.1). Any proposed navigation within the marine park must be performed in consultation with the Great Barrier Reef Marine Park Authority, as appropriate.

Subordinate to the act is the Great Barrier Reef Marine Park Regulation 1983 (Cwlth). These regulations outline offence provisions, compulsory pilotage requirements, details of an environmental management charge and plans for management and review rights of the GBRMP. The regulations declare Port Curtis and its adjacent waters as part of the Port of Gladstone-Rodds Bay Zone B dugong protection area. Dugong protection areas have been declared special management areas under the regulations and the Great Barrier Reef Marine Park Zoning Plan (GBRMPA, 2003). The dugong protection area borders the mainland and extends from the lower limits of The Narrows between Friend Point and Laird Point and follows the west coastline of Curtis Island. It then adjoins to North Point, Facing Island and continues along the west coastline across open waters to Rodds Peninsula.

19.1.2 International Conventions

The following international conventions are relevant to the marine and estuarine environmental values present in, and adjacent to, the study area.

World Heritage Convention

The Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention) provides for the protection of cultural and natural heritage and aims to protect outstanding heritage around the world for current and future generations.

The Great Barrier Reef World Heritage Area (GBRWHA) is listed under the convention and is renowned for its extensive coral reef framework and rich biodiversity. The reef supports broad scale distribution of seagrass, mangrove, benthic and coral reef habitats. The reef was proclaimed as a World Heritage area in 1981 having met all four World Heritage criteria, which at the time were:

- Outstanding example representing a major stage of the earth's evolutionary history.
- Outstanding example representing significant ongoing geological processes, biological evolution and man's interaction with his natural environment.
- Containing unique, rare and superlative natural phenomena, formations and features and areas of exceptional natural beauty.
- Providing habitats where populations of rare and endangered species of plants and animals still survive.

Port Curtis and the study area are both located within the GBRWHA, which extends to the low water mark on the mainland side of The Narrows and includes Curtis Island. The offshore areas east of Curtis Island are included within the Mackay/Capricorn section of the Great Barrier Reef Coast Marine Park (GBRMPA, 1998) (see Figure 1.1).

The Ramsar Convention

The Convention on Wetlands of International Importance, known as the Ramsar Convention, is an intergovernmental treaty that provides for the conservation and sustainable use of wetlands

around the world. The five Ramsar sites listed within Queensland are Great Sandy Strait, Currawinya Lakes, Shoalwater Bay and Corio Bay, Bowling Green Bay and Moreton Bay. Port Curtis is not listed as a Ramsar wetland.

MARPOL Convention

The International Convention for the Prevention of Pollution from Ships (known as MARPOL) aims to prevent pollution of the seas from shipping activity. The convention's rules apply to oil, noxious liquid substances carried in bulk, harmful substances carried in packaged form, sewage, garbage and air pollution from ships. Further information on shipping activities associated with the project can be found in Chapter 28, Traffic and Transport.

19.1.3 National Directory of Important Wetlands

The Directory of Important Wetlands (DSWEPC, 2011b) identifies nationally important wetlands in Australia and provides a knowledge base on wetlands, their variety, and the flora and fauna species that depend on them. It identifies sites and the wetland values present in an area and sites of importance for particular species, including threatened and migratory species. The directory uses a system of classifying wetlands based on that used by the Ramsar Convention in describing Wetlands of International Importance, but was modified slightly to suit the Australian situation in describing wetlands of national importance. It provides the primary data source for identifying potential Ramsar sites in Australia.

Port Curtis is considered a nationally important wetland under the directory as the wetland supports a versatile set of habitat types including salt marshes, mudflats, mangroves and waterbodies. These habitats contribute to a complex and intricate ecosystem that sustains fisheries and supports the health of the environment and residing organisms. The study area is situated within the Port Curtis nationally important wetlands.

19.1.4 State Legislation

The following state legislation is relevant to the protection of marine and estuarine environmental values during the construction, operation and decommissioning of the project:

- *Coastal Protection and Management Act 1995* (Qld). This act recognises the need for the protection, conservation and rehabilitation of coastal resources and biodiversity. It provides guidance and a comprehensive coastal management framework for ecologically sustainable development. Subordinate to the act is the Coastal Protection and Management (Coastal Management Districts) Regulation 2003. The regulation provides a mechanism for developing coastal management districts and associated management plans. The management plan for Curtis Coast Coastal Management District identifies and sets management requirements for 'areas of state significance (natural resources)' that exist within Port Curtis' industry precinct.
- *Environmental Protection Act 1994* (Qld). This act aims to protect Queensland's environment while allowing for ecologically sustainable development. Subordinate to the act are:
  - Environmental Protection Regulation 2008. The regulation lists category A and B environmentally sensitive areas (ESA). The study area includes category B ESAs such as the World Heritage management area and critical habitats or major interest identified by DSEWPC (2011b) and the Port of Gladstone-Rodds Bay dugong protection area (GBRMPA, 2003).
  - Environmental Protection (Noise) Policy 2008. The policy identifies environmental values that are to be enhanced or protected including the health and biodiversity of ecosystems.

The policy includes an objective on acoustic quality aimed at protecting the amenity of the marine area.

- *Fisheries Act 1994* (Qld). This act provides for the management, use and protection of fisheries resources and fish habitats in a way that is ecologically sustainable. It provides a management framework to regulate community aquaculture and other commercial activities. The act protects all marine plants, including seagrass, salt couch and mangroves from being intentionally removed, damaged or destroyed and it identifies the relevant codes that apply if activities propose to remove, damage or destroy marine plants.

  Subordinate to the act is the Fisheries Regulation 2008. The regulation declares fish habitat areas to protect significant marine and estuarine habitats that support ecosystems and sustain fisheries. Seventy fish habitat areas have been assigned along the coast of Queensland. These designated areas are safeguarded from physical disturbance associated with coastal development. The project is not situated in, nor disturbs, any declared fish habitat areas. The closest fish habitat areas to the study area are the Colosseum Inlet, 20 km south of Gladstone, and the Fitzroy River, near the northern end of Curtis Island and southeast of Rockhampton (see Figure 1.1).

  The regulation recognises Port Curtis and its adjacent waters as part of the Port of Gladstone-Rodds Bay Zone B dugong protection area, and declares restrictions for netting use and general activities in Zone A and B dugong protection areas.

- *Marine Parks Act 2004* (Qld). This act supports the conservation of the marine environment and provides for the declaration and establishment of marine parks and associated zoning and management plans. It further recognises cultural, economic, environmental and social relationships within marine parks and surrounding areas.

  Subordinate to the act is the Marine Parks Regulation 2006. The regulation provides for zoning and objectives for such areas within marine parks, regulations associated with entry, use and type of activities permitted within marine parks, as well as review rights. The regulation declares the zoning and protection of the Great Barrier Reef Coast Marine Park, a state-enforced marine park that complements the Commonwealth GBRMP. The boundary extends the entire length of GBRMP and includes the tidal waters and tidal land within the Mackay/Capricorn Management Area, Townsville/Whitsunday Management Area, Cairns/Cooktown Management Area, Far Northern Management Area and the Outer Islands Management Area. The study area is situated outside of, but adjacent to, the Great Barrier Reef Coast Marine Park.

- *Nature Conservation Act 1992 (*Qld). This act is the predominant state legislation that supports the conservation of nature. The act provides for the dedication, declaration and management of protected areas, and protection of wildlife and its habitat in association with ecologically sustainable use of such wildlife. Subordinate to the act are:

  – Nature Conservation (Wildlife) Regulation 2006. The regulation defines the conservation status of native wildlife species in Queensland, broadly classifies non-native species and provides a declared management intent for each class.

  – Nature Conservation (Dugong) Conservation Plan 1999. The plan outlines management strategies necessary to achieve the protection and conservation of the dugong (*Dugong dugon*). Such strategies include reducing threats to seagrass habitats and minimising the impacts of anthropogenic activities through limiting threatening processes and restricting the permitting of use and access to the wildlife. The plan further declares Port Curtis and its

adjacent waters as part of the Port of Gladstone-Rodds Bay Zone B (restricted use) dugong protection area.

  - Nature Conservation (Whales and Dolphins) Conservation Plan 1997. The plan is designed to protect and conserve whales and dolphins in Queensland waters. It outlines management strategies to minimise harm and distress caused by anthropogenic activities such as pollution, noise disturbance and direct contact that may result from the construction and operation of the project.

  - Nature Conservation (Estuarine Crocodile) Conservation Plan 2007. The plan outlines the conservation of viable populations of saltwater (estuarine) crocodile and sustainable use of commercial stock that may be impacted by the project. Crocodile populations, wild or farmed, are not likely to be encountered in the study area.

  - Nature Conservation (Protected Areas) Regulation 1994. The regulation identifies national parks, conservation parks, resource reserves and nature refuges that are of particular importance to marine and estuarine ecology in and adjacent to the study area.

- *Vegetation Management Act 1999* (Qld). This act regulates clearance of native vegetation on freehold and leasehold land and seeks to maintain ecological function in these areas. The act aims to manage vegetation clearing in a way that conserves remnant vegetation, prevents land degradation and biodiversity loss, and reduces greenhouse gas emissions. The act does not apply on all tenures or vegetation types, including grass and mangrove communities (see Appendix 12, Marine and Estuarine Ecology Impact Assessment).

  Subordinate to the act is the Vegetation Management Regulation 2000. The regulation declares the different categories of regional ecosystems in Queensland and vegetation clearing approvals and management plan requirements. The regulation provides a list of 'endangered', 'of concern' and 'of least concern' regional ecosystems for the Southeastern Queensland bioregion. All proposed project infrastructure is located within this bioregion, which includes marine and estuarine plants that may be present in the study area and within areas of potential disturbance.

19.1.5 Policies and Subordinate Legislation

The following policies and subordinate legislation are relevant to the protection of marine and estuarine environmental values during the construction, operation and decommissioning of the project:

- Draft Policy Statement: Use of environmental offsets under the *Environment Protection and Biodiversity Conservation Act 1999* (DEWR, 2007). The statement outlines the position of the Commonwealth Government on environmental offsets under the EPBC Act, and ensures the consistent application of offsets to projects under the act.

- Great Barrier Reef Marine Park Zoning Plan 2003. (Cwlth). This plan, under the Great Barrier Reef Marine Park Act, is the primary planning instrument for the conservation and management of the marine park (see Figure 1.1).

- Marine Parks (Great Barrier Reef Coast) Zoning Plan 2004. (Qld). Developed under the Marine Parks Act, this plan provides the zoning information for the Great Barrier Reef Marine Park.

- Queensland Government Environmental Offsets Policy (EPA, 2008b). The policy aims to address impacts to biodiversity values, which may be lost as a result of development or other activities; and sets out the Queensland Government's policy on offsets.
- Policy for Vegetation Management Offsets (DERM, 2009c). The policy describes vegetation management offsets required for development and infrastructure projects. It aims to ensure the long-term conservation of remnant regional ecosystems, and sets criteria for acceptable offsets.
- Fish Habitat Management Operational Policy (FHMOP 005) (Dixon & Beumer, 2002). This policy, compiled under the Queensland Fisheries Act 1994, guides permit assessments to mitigate impacts to, and provide compensation for, losses to marine fish habitat.
- Recovery Plan for Marine Turtles in (Environment Australia, 2003). Developed under the EPBC Act, the objective of this plan is to reduce detrimental impacts on Australian populations of marine turtles and hence promote their recovery in the wild.
- Policy Statement 2.1 Interactions between offshore seismic exploration and whales (DEWHA, 2008). Developed under the EPBC Act, this policy provides practical standards, framework and guidance to minimise the risk of acoustic injury to whales in the vicinity of seismic survey sources and operations. Standards are also provided for pile driving and other underwater noise sources.

19.2 Assessment Method

The study area for the marine and estuarine assessment included areas of disturbance from project infrastructure within the marine environment below highest astronomical tide as well as the wider surrounding marine environment (Port Curtis) (Figure 19.1). Areas on the mainland and Curtis Island above the highest astronomical tide are not considered as part of this study.

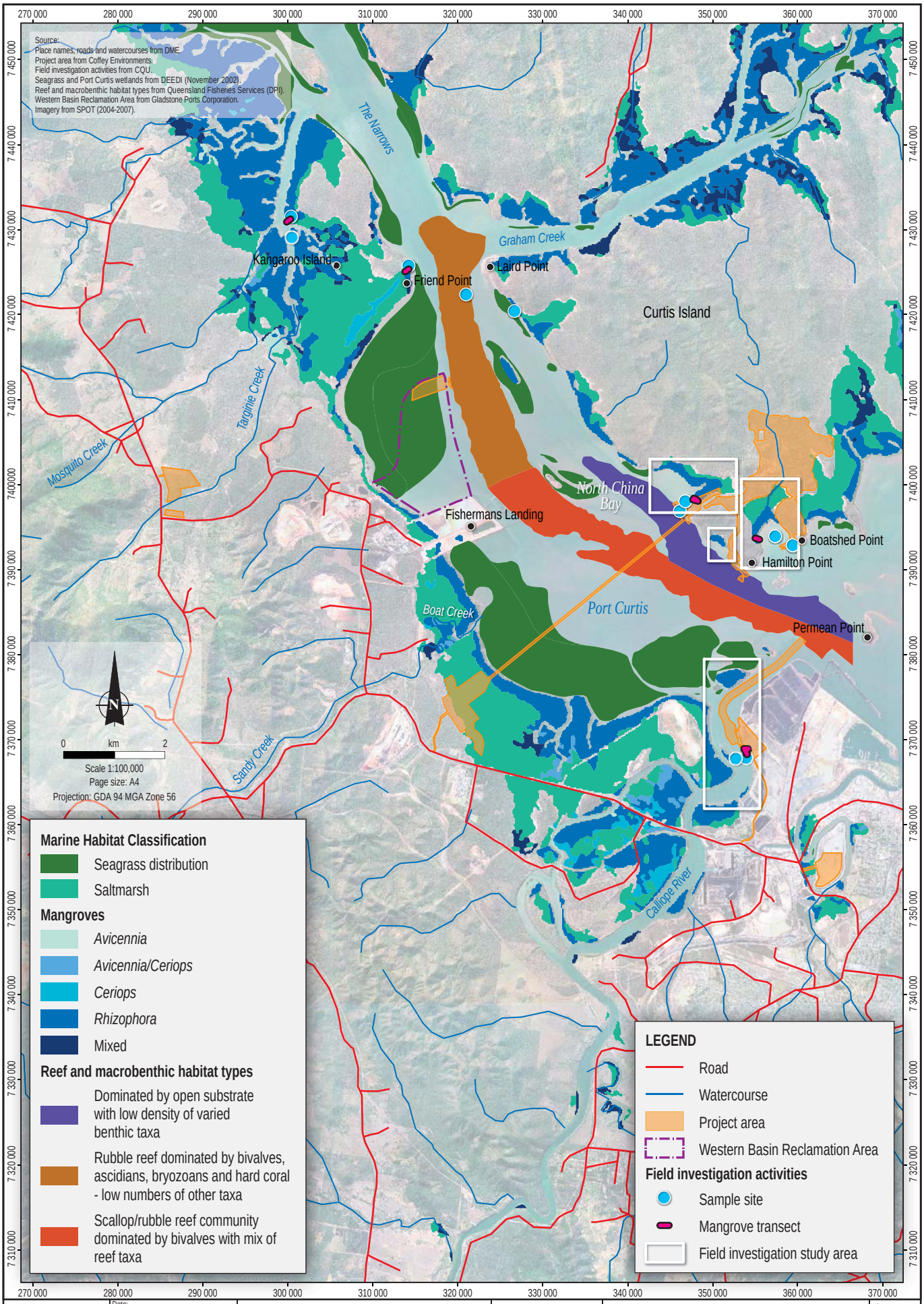
This impact assessment uses the significance method (sensitivity and magnitude) to assess the potential impacts of the Arrow LNG Plant on the marine and estuarine ecological values within the study area, as outlined below.

19.2.1 Baseline Assessment

The baseline environmental values of the marine and estuarine environment of Port Curtis and the project area were established through a literature review and targeted field investigations as outlined below.

Desktop Study

A desktop review of available literature was carried out for Port Curtis and the surrounding estuarine environment. A full reference list of literature used in the impact assessment can be found within Appendix 12, Marine and Estuarine Ecology Impact Assessment. Port Curtis and the surrounding southeast Queensland coastal area have been monitored and studied extensively in recent years, and the large amount of published data available was used to describe the existing characteristics and marine environmental values of Port Curtis and its coastline (including the Wetland *Info* database (DERM, 2011c)).



coffey environments

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Arrow Energy

Arrow LNG Plant

arrow energy go further

Marine and estuarine habitat distribution in the Port Curtis region

Figure No: 19.1

Field Investigations

Field investigations supplemented the desktop study by providing more detailed descriptions of the environmental values at the location of the proposed marine facilities for the project (i.e., the LNG jetty, materials offloading facility (MOF) and mainland launch sites). The field investigations were performed by Central Queensland University.

Two sampling programs (Phase I and Phase II) established and characterised the marine habitat values in the study area. Figure 19.1 shows the location of field investigation study areas, specific field sampling sites and mangrove sampling transects relative to the project area.

The habitats and resources investigated in the field surveys included mangroves, saltmarsh, intertidal and subtidal benthos, seagrass and fish communities. The areas investigated included:

- North China Bay: Location of the LNG jetty.
- South Hamilton Point: Location of a passenger terminal and MOF option.
- Boatshed Point: Location of a passenger terminal and MOF option.
- Calliope River: Location of a mainland marine terminal option (launch site 1) and associated dredging.
- Fishermans Landing: Location of a mainland marine terminal option (launch site 4N) and associated dredging.
- The Narrows area: To provide for a broader area of habitat comparisons in Port Curtis (although The Narrows is outside the direct project study area).

Macroinvertebrate and sediment samples were taken at random coordinates within the field investigation study areas during May 2010 (Phase I) and February 2011(Phase II).

The field investigations focused on the areas of potential marine and estuarine disturbance from the Arrow LNG Plant and aimed to:

- Investigate spatial intertidal and subtidal macroinvertebrate communities.
- Determine sediment particle sizes and organic content at potential development sites.
- Determine mangrove habitat distribution and seagrass bed community composition.
- Investigate fish assemblages within the mangrove habitat, seagrass and soft-sediment areas.

Further information on the study methods, sampling techniques, survey limitations and results can be found in Appendix 12, Marine and Estuarine Ecology Impact Assessment.

19.2.2 Impact Assessment

The marine impact assessment used a conservative approach to identifying impacts. This approach assessed and outlined the worst-case impacts on marine environmental values to accurately represent all potential impacts within the assessment.

Known habitat distributions were laid over known and modelled areas of the direct and indirect areas of disturbance. Direct impacts affect or disturb the environmental values directly. Indirect impacts occur as a result of project activities. For example, clearing of mangroves is a direct impact on the mangroves being removed; increased turbidity within the marine environment as a result of the clearing may be an indirect impact to the surrounding marine habitats. Once areas of direct and indirect impact were known, the maximum extent of impacts from construction of

marine infrastructure, project operations and associated shipping activities for each environmental value or habitat type were selected and assessed throughout the impact assessment.

The information from the desktop and field investigations was used to determine the environmental values of the marine and estuarine ecology in Port Curtis and their sensitivity to change. Assessment of sensitivity takes into account intactness, uniqueness or rarity, resilience to change and replacement potential, in addition to conservational status. If the environmental value has a listed conservation status under the IUCN, Commonwealth and state governments, then it prevails over other recognised listings or importance, and this will determine its sensitivity. If there is no conservation status, then the listing or importance of the environmental value will determine its sensitivity. The criteria used to assess the sensitivity of marine and estuarine ecology values in the assessment are set out in Table 19.1.

Table 19.1 Sensitivity of the environmental value

Sensitivity	Definition
Very high	• An environmental value that is listed as 'critically endangered' under the IUCN and Commonwealth Government or 'international' under state government. • An environmental value that has international listing or importance.
High	• An environmental value that is listed as 'endangered' under the IUCN, Commonwealth or state governments. • An environmental value that has national importance. • An environmental value of essential (local) commercial or recreational requirement or importance in maintaining ecological integrity (even if not otherwise listed).
Medium	• An environmental value that is listed as 'vulnerable' or 'rare' under the IUCN, Commonwealth or state governments. • An environmental value that has state importance. • An environmental value of common or frequent recreational or commercial importance locally.
Low	• An environmental value that is listed as 'near threatened' under the IUCN or 'conservation dependent' under the Commonwealth Government or 'least concern' under the state government. • An environmental value that has regional importance. • An environmental value of occasional recreational or commercial importance locally.
Very low	• An environmental value that is common and is not listed under the IUCN, Commonwealth or state governments. • An environmental value with local importance. • An environmental value of no reported recreational or commercial importance locally.

The magnitude of an impact considers severity, geographical extent and duration in relation to the probability and likelihood of an impact occurring. The criteria (shown in Table 19.2) used to assign magnitude to impacts has been adopted from the Commonwealth Government's 'Matters of National Environmental Significance, Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999'(DEWHA, 2009c) in conjunction with the IUCN (2010) 'Red List Categories and Criteria'.

Table 19.2 Magnitude of the impact

Magnitude	Definition
Very high	• Widespread and severe impacts, over large geographical areas, which may be long lasting and are very likely to happen. • Reduce the extent of an ecological community substantially (e.g., by 90%). • Destroy habitat necessary for an ecological community's survival. • Result in persistent and major adverse changes to an ecological community's life cycle, including breeding, feeding and migration.
High	• Regional impacts, which may be long lasting and are likely to happen. • Reduce the extent of an ecological community by approximately 50%. • Modify habitat necessary for an ecological community's survival. • Result in major adverse changes to an ecological community's life cycle, including breeding, feeding and migration.
Medium	• Localised impacts, which may be long lasting and are likely to happen. • Reduce the extent of an ecological community by approximately 25%. • Fragment habitat necessary for an ecological community's survival. • Result in moderate adverse changes to an ecological community's life cycle, including breeding, feeding and migration.
Low	• Localised impacts, which may be short lived and likely to happen. • Reduce the extent of an ecological community by less than 10%. • Disturb habitat necessary for an ecological community's survival. • Result in minor adverse changes to an ecological community's life cycle, including breeding, feeding and migration.
Very low	• Impact unlikely to occur. • Extent and population of ecological community stable. • Habitat necessary for an ecological community's survival is unlikely to be impacted. • The life cycle of an ecological community, including breeding, feeding and migration, is unlikely to be impacted.

The significance of an impact to an environmental value is determined by the sensitivity of the value itself and the magnitude of the expected change (see Table 19.3).

Table 19.3 Matrix of significance

	Sensitivity of Environmental Value				
Magnitude of Impact	**Very High**	**High**	**Medium**	**Low**	**Very Low**
Very High	Major	Major	Major	Minor	Negligible
High	Major	Moderate	Moderate	Minor	Negligible
Medium	Moderate	Moderate	Minor	Minor	Negligible
Low	Moderate	Minor	Minor	Minor	Negligible
Very Low	Negligible	Negligible	Negligible	Negligible	Negligible

The levels of significance of an impact determined using Table 19.3 are defined below:

- Major significance. An impact that is irreversible, widespread or of high consequence, and about which there is considerable uncertainty on the magnitude and duration or frequency of the impact. The values are unique and, if lost, cannot be replaced or relocated. An impact of this significance is likely to be a key factor in the decision-making process and will raise considerable stakeholder concern.

- Moderate significance. The impact has the potential to cause an actual environmental harm. Typically, such impacts are likely to be important at a regional or district scale and require the application and management of specific environmental controls. This level of impact will influence decision making, particularly when combined with other similar effects.
- Minor significance. An impact that is not trivial or very low in magnitude, duration or frequency. Typically, its effects will be important at a local scale and, when combined with other impacts, could have a more material effect. It is likely to have negligible influence on decision making, but could raise awareness and concern about possible cumulative effects from a range of minor impacts.
- Negligible. An impact that will not result in any noticeable environmental change or effects and which will not influence the decision-making process.

19.3 Existing Environment and Environmental Values

This section describes the existing environmental values that occur within the study area and more widely within Port Curtis to establish the marine and estuarine ecology baseline conditions against which to assess potential impacts of the project. These existing environmental values incorporate both the physical habitat environments and existing flora and fauna. The study area does not include areas above the highest astronomical tide or outside the Gladstone and Port Curtis region.

Many of the region's coastal environments have significant conservation value. The GBRWHA commences at the low water mark on the mainland side of The Narrows and includes Curtis Island, while the offshore areas east of Curtis Island are included within the Mackay/Capricorn section of the Great Barrier Reef Coast Marine Park (see Figure 1.1).

Port Curtis is also included in the list of nationally important wetlands in Queensland, meeting all six of the criteria for inclusion. Areas in and around Port Curtis provide important habitats used by a range of species, including the dugong (*Dugong dugon*), the potentially endemic Australian snubfin dolphin (*Orcaella heinsohni*) and Indo-Pacific humpback dolphin (*Sousa chinensis*), six of the world's seven species of protected marine turtles, sea snakes, the estuarine crocodile, fish species (including seahorses and pipefish), pelagic and benthic invertebrates and plankton. The project is not situated in any declared fish habitat areas. The closest fish habitat areas to the study area are Colosseum Inlet situated 20 km south of Gladstone and the Fitzroy River located near the northern end of Curtis Island.

The environmental values within the study area are divided into the following categories: the physical environment and habitat zoning, flora, and fauna. Each is discussed further below.

19.3.1 Physical Environment and Habitat Zoning

Curtis Island and areas of Port Curtis fall within the GBRWHA. Within the World Heritage area, Port Curtis and its northern extension, The Narrows (approximately 7 km from launch site 4N), form a narrow coastal embayment of approximately 200 km^2, that separates Curtis Island from the mainland.

The marine and estuarine environment of Port Curtis is characterised by a high tidal range of greater than 4 m, consequential tidal currents and extensive intertidal areas. Port Curtis is influenced by freshwater inflow from a number of rivers and creeks, particularly the Calliope and Boyne rivers. The strong tidal currents that flush the numerous creeks and tributaries maintain naturally high levels of turbidity and suspended sediments.

The high tidal range influences the ecology of the area, resulting in a typical pattern of intertidal and coastal zonation from:

- Saltmarsh and mudflat areas, which are inundated only during extreme spring tides.
- Intertidal mudflats and mangroves, which dominate estuarine areas of Targinie Creek and North China Bay on the western shore of Port Curtis.
- Subtidal mudflats and tidal channels.
- Seagrass beds extending from intertidal to subtidal areas.
- Rock and reef habitats extending intertidally and subtidally from the rocky headlands, predominantly on Curtis Island on the eastern shore of Port Curtis.

Figure 19.1 shows the distribution of marine and estuarine flora, reef and macrobenthic habitats located within the study area and Port Curtis. Areas surrounding Port Curtis, such as The Narrows, are outside the direct project study area and are discussed to allow for habitat comparisons.

Benthic Zone

The benthic zone within Port Curtis encompasses the sediment substrate and subsurface layers below the waterbody, and supports an array of small and microscopic organisms both on and below the surface of the sediments. Benthic fauna is an important component of the food chain within the Port Curtis ecosystem and assists in sediment and nutrient recycling.

The benthic zone along the coastal margins in the study area has a high sensitivity and has national importance for its contribution to wetlands listed under the Directory of Important Wetlands of Australia (DSEWPC, 2011b).

Reef and Rock Substrate

Rubble reef areas and coral bommies cover approximately 15% of the study area substrate within Port Curtis, and support a broad range of organisms including bivalves, ascidians, bryozoans and hard corals. A combined scallop and rubble reef covers approximately 16% of the study area substrate and is dominated by scallops, bivalves and mixed reef communities. Overall, Port Curtis supports approximately 3,341 ha of reef.

Rock substrate is widespread throughout Port Curtis (Plate 19.1) and is typically composed of oyster-encrusted boulders and rubble in the coastal margins. The rock provides a solid substrate for attachment of organisms such as algal flora, barnacles, oysters and tubeworms. The precise distribution of rock substrate within the study area has not been mapped.

The reef habitat is not a major feature of the Port Curtis area but its sensitivity in the study area is medium on the basis of vulnerability of reef systems to sedimentation and its contribution to the community assemblage and overall population and diversity of the GBRWHA.

The sensitivity of rock substrate in the study area is medium**.** The intertidal distribution of this substrate contributes to the composition of the wetlands under the Directory of Important Wetlands of Australia (DSEWPC, 2011b).

Source: Coffey

Plate 19.1
Example of rock substrate at Hamilton Point

Intertidal Mudflats

Intertidal mudflats include the zone exposed at low tide and submerged at high tide. Mudflats support a high biodiversity and biomass of benthic species, support fisheries productivity and act as a feeding ground for migratory birds. Soft mudflats composed of fine sediment are exposed during low tide for approximately 300 m at North China Bay, Kangaroo Island and Friend Point.

The sensitivity of intertidal mudflats is high and can be defined as having national importance as they are a component of the wetlands under the Directory of Important Wetlands of Australia (DSEWPC, 2011b).

19.3.2 Flora

Saltmarsh, mangroves and seagrass beds are all found in Port Curtis and provide important habitats for fauna species.

Saltmarsh

Saltmarsh environments typically occur landward of mangroves in the extreme high tide areas and are inundated only at the highest spring tides. Species present include halophytic (salt tolerant) grasses such as salt couch (*Sporobolus virginicus*) and saltmarsh species such as the bead weed (*Sarcocornia quinifleflo*ra) (Plate 19.2).

The most extensive areas of saltmarsh in Port Curtis are around Targinie Creek and in the inner embayments of North China Bay and Boatshed Point. Saltmarsh areas also occur to the west of Kangaroo Island, in the southwest of Port Curtis and at the southeast of Curtis Island. The combined area of saltmarsh and salt-tolerant species in the Port Curtis region is approximately 4,573 ha (Danaher et al., 2005).

The sensitivity of saltmarsh habitat is medium as the regional ecosystem in which the saltmarsh species occurs is listed as ‘least concern’ under the Vegetation Management Regulation 2000.

Mangroves

Mangroves occupy the intertidal margins of much of Port Curtis. They provide benefits to the wider ecosystem through their high productivity and erosion protection, nutrient filtering and recycling functions. The structurally complex habitat provides nursery areas for the juveniles of commercially and recreationally important species of fish and crustaceans. Extensive areas of mangroves occur around Port Curtis and Curtis Island; the largest areas occur within Targinie Creek and Graham Creek, and in the southwest, between Fishermans Landing and the Calliope River.

Five species of mangrove were recorded in Port Curtis including red mangrove *(Rhizophora stylosa*), yellow mangrove (*Ceriops tagal*), grey or white mangrove (*Avicennia marina*), myrtle mangrove (*Osbornia octodonta*), and black or river mangrove *(Aegiceras corniculatum*). Examples of these mangrove communities are shown in Plate 19.3 and Plate 19.4.

The sensitivity of mangrove habitat is medium. While the species present are listed nationally under the Directory of Important Wetlands of Australia (DSEWPC, 2011b), their habitat is listed as a ‘least concern’ regional ecosystem under the Vegetation Management Regulation 2000.

Seagrass

Seagrass beds provide several important ecological functions. They help stabilise sediments, trap and recycle nutrients, and provide habitat for juvenile fish and crustaceans. Seagrass areas also

Source: Coffey

Plate 19.2
Example of salt couch and bead weed along Calliope River

Source: Coffey

Plate 19.3
Example of *Rhizophora* along the Calliope River

Source: Coffey

Plate 19.4
Example of *Avicennia* at Hamilton Point

provide feeding areas for vulnerable and endangered species, such as the dugong and several species of marine turtles. Seagrass areas are now protected in legislation and large areas (as much as 4,000,000 ha) of seagrass are protected or monitored within the GBRWHA and the GBRMP.

Seagrass beds are scattered throughout Port Curtis. The main areas are in the west close to Gladstone and Fishermans Landing. The combined area of all intertidal seagrass beds in Port Curtis is approximately 4,500 ha.

The sensitivity of seagrass habitat is assessed as high for its role in supporting populations of dugongs and green turtles and for its ecological function within the GBRWHA.

19.3.3 Fauna

Port Curtis and its surrounding waters are rich in biodiversity and support a large marine fauna population, including several species listed under either the EPBC Act or on the IUCN Red List. Dugongs, marine turtles, cetaceans, fish, sea snakes, seahorses and pipefish all occur within the Port.

The area also represents the southern limit of habitat for saltwater crocodiles. Macrobenthic and plankton species are also present within the study area.

The sensitivity of these species is summarised below, taking into account their conservation (and commercial) importance to the area.

Dugongs

Dugong (*Dugong dugon)* is listed as a protected migratory species under the EPBC Act and as a vulnerable species by IUCN (2010) and the Nature Conservation Act. Large populations (estimated at 14,000 individuals) have been observed within the GBRMP, and their presence has attributed to the area being listed as a World Heritage area and the designation of the Zone B dugong protection area. The entire study area falls within the dugong protection area.

Dugong populations are known to feed on the seagrass beds within Port Curtis during their migration along the Queensland coast. They can feed in large herds of approximately 140 individuals, grazing in a single location for four weeks or longer. The long lifespan and low reproduction rate of the dugong means the species population recovery is potentially slow, and the animals are vulnerable to both natural and anthropological factors, including boat strike, underwater noise, Indigenous hunting, commercial fishing or trawling and destruction or fragmentation of habitat.

The sensitivity of the dugong in the study area has been defined as medium due to their protected and vulnerable conservation status under IUCN, Commonwealth and state government listings and regulations.

Marine Turtles

Six of the seven species of marine turtles worldwide occur within Queensland waters and all six are thought to or could occur within Port Curtis and the study area. All six species are listed as vulnerable or endangered by the EPBC Act and Nature Conservation Act, and as vulnerable, endangered or data deficient by the IUCN (2010). The conservation status of these marine turtles is shown in Table 19.4.

Table 19.4 Conservation status of marine turtles in Queensland waters

Scientific Name	Common Name	IUCN Red List	EPBC Act	Nature Conservation Act (Wildlife) Regulation
Natator depressus	Flatback turtle	Data deficient	Vulnerable	Vulnerable
Chelonia mydas	Green turtle	Endangered	Vulnerable	Vulnerable
Caretta caretta	Loggerhead turtle	Endangered	Endangered	Endangered
Eretmochelys imbricata	Hawksbill turtle	Critically Endangered	Vulnerable	Vulnerable
Lepidochelys olivacea	Olive ridley turtle	Vulnerable	Endangered	Endangered
Dermochelys coriacea	Leatherback turtle	Critically Endangered	Vulnerable	Endangered

The flatback, green and loggerhead turtles all nest and forage within the GBRMP and GBRWHA. Some individuals nest within Port Curtis (with the closest nesting area at Southend, 8 km from the proposed LNG plant site and marine facilities) (Figure 19.2). The remaining three species either have wider worldwide distributions or are less likely to nest near Port Curtis, and as such are not mentioned further in this assessment.

The marine turtle species found within Port Curtis display a long lifespan, low reproductive rate and high site fidelity. These features restrict the rate of population recovery and, as such, could render the populations more vulnerable to anthropogenic impacts such as loss of foraging habitat, boat strike, and project lighting (light glare can lead to disorientation in both nesting adults and emerging hatchlings).

The distribution and nesting sites of the flatback turtle are restricted to coastlines along Australian continental shelf waters. They are the dominant species in the Port Curtis region, with an intermediate-sized nesting population of 51 females around Connor Bluff (Southend), Curtis Island (Limpus et al., 2006). The breeding season generally starts in mid-October, with nesting from late November to early December, and hatching between December and March. The sensitivity of the flatback turtle is medium and the species is listed as having vulnerable conservation status by Commonwealth and state governments.

The green turtle has a distribution predominantly within tropical and subtropical regions. The southern Great Barrier Reef region, which encompasses Port Curtis, is known to support approximately 8,000 individuals (DEWHA, 2010). The species occasionally nests on beaches near Southend, Curtis Island. Breeding for green turtles occurs from September to November, nesting from mid-October to early April, and hatching between December and May. The sensitivity of the green turtle is high and the species is listed as having endangered conservation status by the IUCN (2010).

Loggerhead turtles have a distribution predominantly within subtropical and tropical regions. In eastern Australia, there are approximately 500 nesting females per year (Limpus & Limpus, 2003). The loggerhead turtle nests intermittently within the Port Curtis region. Breeding begins in late October to December, nesting occurs from October to March, and hatching from December to May. The sensitivity of the loggerhead turtle is high and the species is listed as having endangered conservation status by the IUCN (2010) and Commonwealth and state governments.

Cetaceans

Thirteen species of cetaceans (i.e., whales, dolphins and porpoises) have known ranges that

Source:
Place names, roads and watercourses from DME. Project area from Coffey Environments. Imagery from ESRI (currency unknown).
Port of Gladstone port limits digitised by Coffey Environments from GPC figure 'Port of Gladstone port limits and channel and berth depths' (04/10/07).
Turtle nesting sites digitised by Coffey Environments from EPA figure 'Shorebirds and Turtles'.
Turtle nesting rates courtesy Col Limpus QPWS Senior Principal Conservation Officer Parks and Wildlife Strategy Research Coordination Unit.
Nesting rates recorded between 1968 - 1999, not all records shown.

coffey environments

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Arrow Energy

Arrow LNG Plant

arrow energy go further

Turtle nesting sites in the Gladstone region

Figure No: 19.2

include the waters of Port Curtis. Ten of these species are listed under the IUCN Red List (2010) ranging from 'least concern' to 'near threatened' and 'endangered'. These species and their conservation status are detailed in Table 19.5.

Cetaceans most likely to be found regularly within Port Curtis are the Australian snubfin dolphin and the Indo-Pacific humpback dolphin. Both species are listed on the IUCN Red List as near threatened. The blue whale is listed as endangered under the IUCN Red List, although it is only likely to occur offshore around the continental shelf and not in Port Curtis. While most of the other cetacean species listed in Table 19.5 have the potential to migrate through Port Curtis, the three species described above have a higher international and national conservation status and have previously been sighted in the Port Curtis region. As such, they are discussed further.

The main habitat of the Australian snubfin dolphin and the Indo-Pacific humpback dolphin is shallow coastal waters in or adjacent to modified environments such as dredged channels, breakwaters and river mouths (Parra, 2006). These habitats exist along the majority of the Queensland coastline (including Port Curtis) and support foraging and mating activities. Generally, adult female cetaceans have a low reproductive rate and calve only every few years.

Table 19.5 Conservation status of whales and dolphins (cetaceans) in Queensland waters

Scientific Name	Common Name	IUCN Red List	EPBC Act
Delphinus delphis	Common dolphin	Least concern	N.A.[2]
Grampus griseus	Risso's dolphin[1]	Least concern	N.A.[2]
Lagenodelphis hosei	Fraser's dolphin	Least concern	N.A.[2]
Orcaella heinsohni	Australian snubfin dolphin[1]	Near threatened	N.A.[2]
Sousa chinensis	Indo-Pacific humpback dolphin *	Near threatened	N.A.[2]
Stenella attenuata	Spotted dolphin	Least concern	N.A.[2]
Tursiops truncatus	Bottlenose dolphin	Least concern	N.A.[2]
Balaenoptera musculus	Blue whale[1]	Endangered	Endangered
Megaptera novaeangliae	Humpback whale[1]	Least concern	Vulnerable
Peponocephala electra	Melon headed whale	Least concern	N.A.[2]

[1] Indicates species listed on the Wetland*Info* database (DERM, 2011c) and have been sighted within the Fitzroy natural resource management region and the Gladstone local government area.

[2] These species are included in the EPBC list of marine species but are not listed as extinct in the wild, critically endangered, endangered, vulnerable or conservation dependant under the EPBC list of threatened fauna.

Anthropogenic activities and coastal developments along the Queensland coast that can have an impact on cetacean species survival include gill netting activities, pollution, vessel traffic (and associated noise), boat strike and overfishing.

The sensitivity of the Australian snubfin dolphin and the Indo-Pacific humpback dolphin is low given their IUCN and state government, near-threatened conservation status.

The sensitivity of the blue whale is high given its endangered conservation status listing under both the IUCN and Commonwealth Government. This species is unlikely to be in the study area.

Fish and Shellfish

Many fish and shellfish species occur within the marine and estuarine waters around Port Curtis. The habitats within the study area provide spawning, nursery and feeding areas for recreationally and commercially important fishing species.

The study characterised fish and invertebrate communities in mangrove-lined, shallow-water habitats within Port Curtis. In total, 1,262 fish and macroinvertebrates representing 29 species were collected. The species included prawns, small bait fish and larger species of fish. In the deeper channels of Port Curtis, 36 fish species and 124 macroinvertebrate species (which represent large-sized, deep-water species) were recorded. The study found that 53% of fish and nekton sampled were offshore spawners that used estuaries as nursery grounds during juvenile stages. The banana prawn (*Fenneropenaeus merguiensis*) and the common ponyfish (*Leiognathus equulus*) are the most common species to use estuaries as nursery grounds during their juvenile stages of growth.

Most recent records indicate that the highest recreational fishing catch numbers in the Gladstone area include species of bream (*Acanthopagrus australis*), mullet (*Mugil cephalus*), sweetlips (*Lethrinus miniatus*), trevally (*Pseudocaranx dentex*), tropical snapper (*Lutjanus lutjanus, Lutjanus rivulatus* and *Lutjanus fulviflamma*), whiting (*Sillago sihama* and *Sillago analis*) and mackerel (*Rastrelliger kanagurta*) (DPIF, 2011).

Recreational fishing is one of the most easily accessed recreational activities in central Queensland, and Gladstone has one of the highest boat ownership rates per capita in Australia. The status of recreational fishing is a key indicator of environmental health, productivity and sustainability.

The species targeted by recreational fishers in Port Curtis and the surrounding marine areas are of regional importance. No species of conservation importance were recorded within the targeted field studies. The overall level of sensitivity of fish and shellfish is medium on the basis of the presence of species of recreational fishing importance. Recreational fishing in Port Curtis and surrounding waters is discussed further in Chapter 26, Social.

Port Curtis and surrounding waters also provide key commercial fishing grounds. All common species identified extend in range beyond the Port Curtis region to areas around northern Australia and, for some species, to southern Australia as well. Commercial fisheries are typically classified based on the targeted species, the fishing equipment used and infrastructure present. These include trawl, net, line and pot fisheries, scallop and fish processing and wholesale marketing. Commercial fishing in Port Curtis and surrounding waters is discussed further in Chapter 26, Social, and Chapter 27, Economics.

Introduced Species and Pest Species

A 2001 survey within Port Curtis collected information on native, introduced and pest species within the marine environment (Lewis et al., 2001). The study described 10 introduced species in Port Curtis, none of which were recognised as pests and are established elsewhere throughout Australia and worldwide.

Port Curtis is part of the GBRWHA. The sensitivity of the study area to introduced or pest species is very high and can be defined as having international importance given that many organisms could be transported from foreign ports into Port Curtis and into the World Heritage area.

Sea Snakes

Australia has 33 of the world's 54 described species of sea snake. The Species Profile and Threats database (DSEWPC, 2011d), a subordinate of the EPBC Act, identifies 12 sea snakes listed as protected species with an indicative range extending into the study area and the surrounding regions. However, due to limitations in the field studies, no individuals were recorded in the study area. None of these species are recognised on the IUCN Red List (2010). The sensitivity of sea snakes in Port Curtis is medium.

Saltwater Crocodiles

The saltwater crocodile is protected under the EPBC Act and is recognised as vulnerable under the Nature Conservation (Wildlife) Regulation. Crocodiles are known to inhabit reef, coastal and inland watercourses typically north of the tropics, and their habitat extends to the Gladstone region.

The southeast Queensland region is thought to support a moderate density of saltwater crocodiles despite the low quality in nesting and living habitat (Read et al., 2004; Taplin, 1987). Surveys conducted within the region during 1994 and 2000 recorded 434 non-hatchling crocodiles, approximately 10% of the Queensland crocodile population. No saltwater crocodiles were observed during the field surveys.

The sensitivity of the saltwater crocodile is medium as it is defined as 'vulnerable' under the Nature Conservation (Wildlife) Regulation.

Seahorses and Pipefish

Selected species of syngnathid fish (seahorses and pipefish) have been recognised to hold significant environmental value and are listed under the EPBC Act. The Species Profile and Threats database (DSEWPC, 2011d) lists syngnathid fishes as protected species. Only one species is recognised on the IUCN Red List (2010), and it is rated as data deficient.

Limited published information exists on the habitat preferences of syngnathid fishes although they have an indicative range extending into Port Curtis and the surrounding regions. As no video recording or diving was performed during the field studies, no individuals were recorded in the area. The sensitivity of pipefishes and seahorses is medium. Although listed under the EPBC Act, the species do not have any conservation status and are not on the IUCN Red List.

Macrobenthic Communities

Macrobenthic communities include macroinvertebrate species that live within and on the seabed sediments. They play an important role in maintaining water quality and recycling nutrients, and form the basis of the food chain for higher trophic levels.

The baseline survey characterised the intertidal and subtidal macrobenthic communities within Port Curtis. The most common phyla included polychaete worms 38%, molluscs 31%, and crustaceans 28%, with nemerteans and pycnogonids being the least common (less than 1%). Molluscs (*Mactra abbreviate*), crustaceans (*Corophium cf. acutum,* and *Ogyrides delli*) and annelid worms (*Glycera* sp. and *Eunice vittata)* were the most abundant species.

The sensitivity of macrobenthic communities in the study area is very low as they can be defined as having local importance. Community total abundance and species evenness are similar within both the project area and the wider Port Curtis area.

Plankton

Plankton are small or microscopic organisms that float or drift in the water column and include both phytoplankton (plants) and zooplankton (fauna), ranging from larval forms of fish and many invertebrates. Small crustaceans such as copepods, shrimps and their larvae represent a large proportion of organisms that make up zooplankton. Such organisms graze on phytoplankton and form a vital pathway for the transfer of organic carbon from phytoplankton to organisms higher up the food chain.

These planktonic communities have not been studied specifically, as one-off sampling would not give an accurate representation of species present and their relative abundance. These

communities are considered where impacts could potentially affect larval life-cycle processes and integrity of the ecosystems in Port Curtis, particularly the disruption to the water column during construction activities.

The sensitivity of plankton in the study area is very low and can be defined as having local importance given that many organisms undergo larval life-cycle processes and support ecosystems in Port Curtis.

19.4 Issues and Potential Impacts

This section identifies proposed project activities that may have an impact on the existing marine and estuarine environment and their values as a result of construction, operation and decommissioning. Issues and impacts identified and assessed include:

- Loss and disturbance of marine and estuarine habitat.
- Impacts on marine and estuarine fauna by:
  - Boat strike.
  - Underwater noise.
  - Lighting.
- Loss of commercial and recreational fishing access.
- Introduced species and pest species.
- Shipping activities and accidents.

Brine from the desalination plant will be discharged into Port Curtis via an outfall at Boatshed Point. Modelling has shown that high tidal flushing characteristics found within Port Curtis provide a rapid initial dilution and dispersion. This dispersion allows water quality to reach close to background salinity within 10 m of the outfall and well away from the nearest sensitive seagrass beds (approximately 500 m from Boatshed Point). The potential impact from brine discharge is not considered further within this chapter.

Town water, seawater or fresh water (from the reverse osmosis plant) will be used to hydrostatically test the feed gas pipeline and the LNG storage tanks. Test water will be discharged to the sea. If biocides or oxygen scavengers are used, the test water will be tested and treated as necessary before discharge. The potential impact from the discharge from hydrostatic testing is not considered further in this chapter.

Impacts from the discharge of brine and hydrostatic test water on marine water quality are discussed further in Chapter 16, Marine Water Quality and Sediment.

The movement of the LNG carriers into and out of Port Curtis and the associated operation of manoeuvring tugs may cause resuspension of bottom sediments into the water column and potential remobilisation to sensitive areas such as seagrass. The nearest seagrass beds are 1 to 2 km from the LNG jetty and turning areas for the LNG carriers. The frequency of vessel visits will not result in cumulative effects and, overall, impacts are likely to be low and are not considered further.

19.4.1 Loss and Disturbance of Marine and Estuarine Habitat

The areas of marine and estuarine habitat that will be directly occupied or otherwise affected by the project infrastructure (such as the LNG jetty, MOF and launch site 1) include intertidal mudflats, reefs and rocky substrate, benthic sediments, mangroves and saltmarsh communities. During the construction phase, these habitats will be removed or buried as they are replaced by project infrastructure or dredged to provide access to the facilities for construction and operation

(such as the Boatshed Point and Hamilton Point South MOFs, temporary workers' accommodation facilities (TWAFs) 7 and 8, the LNG plant and ancillary facilities and the tunnel entry shaft and spoil disposal areas). No seagrass beds will be directly affected by these construction activities. Additional areas adjacent to those directly impacted may be affected by the lateral spread of construction-induced increases in turbidity (e.g., from dredging) and by sedimentation from construction equipment outside the footprint area; consequently, a buffer of 5 m has been included in the assessment.

The maximum direct loss of habitat for each habitat type is estimated to be 58.2 ha of saltmarsh (majority of loss at the mainland tunnel entry area and spoil disposal area), 5.3 ha of benthic zone and intertidal mudflats (at the Boatshed Point MOF, LNG jetty sites and associated dredging sites), 5.78 ha of mangroves (at the LNG plant site) and 0.14 ha of reef habitats (based on launch site 4N, which is a larger area than for launch site 1) (see Figure 19.1).

In addition to the direct habitat loss outlined above, an area of less than 0.1 ha of the benthic zone and intertidal mudflats will be indirectly affected during operational activities.

The magnitude of the direct and indirect impacts of clearing and dredging of habitat and the assessed significance are set out in Table 19.6. The impacts of clearing of mangroves and mudflat habitats are further discussed in Chapter 13, Surface Water Hydrology and Water Quality, and Chapter 17, Terrestrial Ecology.

Once built, the hard surfaces of the LNG jetty and wharf structures will provide settlement surfaces for encrusting marine fauna and corals. These habitats will also attract fish, resulting in a positive impact to adjacent areas.

Table 19.6 Significance of direct and indirect impacts on marine habitats from clearing and dredging

Value	Sensitivity	Impact	Area Affected (ha)	Magnitude	Significance
Mangrove	Medium	Direct: loss and disturbance of marine and estuarine habitat (clearing).	5.8	Low	Minor
		Indirect: turbidity plumes from dredging.	Nil	Low	Minor
Saltmarsh	Medium	Direct: loss and disturbance of marine and estuarine habitat (clearing).	58.2	Medium	Minor
Seagrass	High	Direct: loss and disturbance of marine and estuarine habitat (clearing).	Nil	Very Low	Negligible
		Indirect: turbidity and sedimentation from dredging.	Nil	Low	Minor
Benthic zone and intertidal mudflat	High	Direct: loss and disturbance of marine and estuarine habitat (clearing or dredging).	5.3	Low	Minor
		Indirect: turbidity and sedimentation from dredging.	less than 0.1	Medium	Moderate

Table 19.6 Significance of direct and indirect impacts on marine habitats from clearing and dredging (cont'd)

Value	Sensitivity	Impact	Area Affected (ha)	Magnitude	Significance
Reef and rock substrate	Medium	Direct: loss and disturbance of marine and estuarine habitat (clearing or dredging).	0.3	Low	Minor
		Indirect: turbidity and sedimentation from dredging.	Nil	Low	Minor

19.4.2 Impact on Marine Fauna

Impacts from the construction, operation and decommissioning of the project include mortality or injury to marine fauna due to boat strike, underwater noise, or behaviour modification due to site lighting.

Boat Strike

Injury and mortality to dugongs, turtles and cetaceans from marine vessel activity in Port Curtis and the Queensland coast are linked primarily to boat strike.

Most vessels within Port Curtis operate in shallow coastal waters; habitats where dugongs, turtles and cetaceans are commonly found. Deeper waters of the port can provide a safe refuge for marine mammals with the ability to dive and this behaviour has been adopted by dugongs and cetaceans. This behavioural instinct relies on hearing ability and reaction speeds. If an individual does not detect or react to an approaching vessel, there is a greater risk of boat strike.

Various classes of vessels will be used during the construction, operation and decommissioning of the project including LNG carriers, LPG vessels, LNG carrier escort tugs, dredgers and barges. These vessels are typically low speed with a low operating frequency. High-speed, high-frequency passenger ferries will also operate between Curtis Island and the mainland launch site.

Table 19.7 sets out the estimated number, type and frequency of marine vessels required for the project. The magnitude of the impact of boat strike on marine mammals is high as any individuals killed or injured could affect the local populations and cause increased public concern. The significance of this impact is **moderate** for dugongs, turtles and cetaceans.

Table 19.7 Estimated type, number and frequency of marine vessels for the Arrow LNG Plant

Type	Number	Frequency[1]
Fast Cat Ferry	2	10 return trips per day
RoPax Ferry	1	10 return trips per day
Barge	1	60 to 70 per year
LNG carrier	1	240 return trips per year
LPG vessel	1	1 return trip in the first year
LNG escort tug	4	960[2] per year
Cutter suction dredging vessel	1	To be confirmed[3]
Support vessel	1	To be confirmed[3]
Backhoe dredging barge	1	To be confirmed[3]
Backhoe support tugs	2	To be confirmed[3]

[1] Based on four LNG trains operating

[2] Based on four tugs (two active and two on standby) per LNG carrier per one-way journey.

[3] Frequency of dredge vessels (including tugs and support vessels) will be included in the dredge management plan.

Underwater Noise

Intense, human-generated underwater sounds from activities such as seismic surveys and pile driving may have the potential to interfere with the behaviour of marine fauna, particularly marine mammals that communicate and navigate using sound. Other effects can include damage to swim bladders of some fish species and mortality to benthic plankton and invertebrates.

The main sources of underwater noise arising from construction include pile driving, movements of vessels carrying equipment and personnel, and dredging activities in the Calliope River and at several other locations within Port Curtis (see Chapter 8, Project Description: Dredging). During operation of the project, the main source of noise will be from the movements of the LNG carriers and associated tugs manoeuvring them alongside the LNG jetty.

The magnitude and significance of the impact of underwater noise on marine fauna is summarised in Table 19.8.

Table 19.8 Significance of impacts of underwater noise on environmental values in the Port Curtis region

Source	Receptor	Sensitivity	Magnitude	Significance
Pile driving	Invertebrates	Low	High	Minor
	Plankton	Very Low	High	Negligible
	Fish	Medium	High	Moderate
	Marine turtles	High/Medium	High	Moderate
	Cetaceans	Medium	High	Moderate
	Dugong	Medium	High	Moderate
Shipping	Marine turtles	High/Medium	Medium	Moderate
	Cetaceans	Medium	Medium	Minor
	Dugong	Medium	Medium	Minor
Dredging (cutter suction)	Marine turtles	High/Medium	Medium/Low	Moderate/minor
	Cetaceans	Medium	Medium/Low	Minor
Dredging (backhoe)	Marine turtles	High/Medium	Medium	Moderate/minor
	Cetaceans	Medium	Medium	Minor

Lighting

The LNG jetty, MOF, mainland launch site and the LNG plant will be lit for safety and security purposes during construction and operation. The LNG plant will also generate light from elevated flares with a potential height of 110 m. The elevated flare will be pilot-lit and, under normal operating conditions, there will not be continuous flaring.

Artificial light can modify natural illumination and cause disruption to visual cues of marine organisms and, in particular, can disorientate marine turtles and affect the behaviour of nesting adults and emerging hatchlings (Limpus, 1971). The closest turtle-nesting beach is around Southend, approximately 8 km from the LNG plant site in a direct line. Light glow generated by the LNG plant could affect the behaviour of marine turtles.

The visual assessment for the Arrow LNG Plant noted that, in addition to the general plant lighting, substantial levels of light from the venting flare could be viewed directly from Southend (see Chapter 23, Landscape and Visual).

Nesting females of all turtle species demonstrate site fidelity to their natal beach. Offsets cannot compensate for the illumination of the facility on the nesting beaches at Southend or the direct impact it may have on the local turtle population (see Figure 19.2). The magnitude of impact of project lighting on turtle populations is medium on the basis that the LNG plant is some distance away from the nearest nesting sites and the project is not the only source of industrial light in the area. However, there are potential adverse effects to breeding success, and the significance of the impact will be **minor** for the flatback turtles or **moderate** for the green and loggerhead turtles.

19.4.3 Impact on Recreational and Commercial Fishing Access

The Port Curtis region supports significant recreational and commercial fishing. Marine and estuarine exclusion zones will be in place during construction and operation for the safety and security of employees and the community, as well as for overall security of the project. There will be a small loss of recreational and commercial fishing access in these areas. Commercial fishers will be prohibited under the Fisheries Regulation 2008 from setting nets within 250 m of the LNG jetty. Recreational fishers (including project personnel when not on duty) will not be able to access areas proposed for the LNG jetty, MOF and mainland launch site. The significance of impacts on recreational and commercial fishing access is discussed further in Chapter 26, Social.

19.4.4 Introduced Species

Introduced and pest species could cause significant economic, environmental and social impacts in Port Curtis and at a state level. Most marine and estuarine introductions occur when organisms are transported in the ballast water of ships. The greatest risk of introducing invasive species is the frequency of LNG carriers moving between Port Curtis and foreign ports. Since the operation of the port in 1914, few introduced species have become established. LNG carriers will move in and out of the port approximately 50 times per month and could bring in introduced or pest species. The magnitude of this impact, due to the low likelihood of occurrence, is low and the significance is **minor**.

19.4.5 Shipping Activities and Accidents

Port Curtis, the GBRMP, the GBRWHA and surrounding waters are environmentally significant and sensitive areas that support rich biodiversity. Outside the study area, LNG carriers travelling through the marine park and surrounding waters have the potential to spill or discharge oil, chemicals, sewage, grey or black water and ballast water; generate litter or garbage; and collide, ground, anchor or sink in the park.

These impacts could displace, smother or lead to the mortality of flora and fauna and alter or cause physical damage to habitats. The greatest risks from shipping activities relate to the frequency of LNG carriers moving between Port Curtis and foreign ports and the lack of compliance with maritime law, operational procedures or pilotage.

The magnitude and significance of the impacts on the marine and estuarine ecology values from shipping activities and accidents is presented in Table 19.9.

Table 19.9 Significance of shipping activities and accidents on marine and estuarine ecology values in the Port Curtis region

Incident Type	Magnitude	Significance
Large volume oil, hydrocarbon and chemical spills	High	Major
Small volume oil, hydrocarbon and chemical spills	Medium	Moderate
Sewage, grey water and ballast spills	Low	Moderate
Litter	Low	Moderate
Grounding	Medium	Moderate
Anchoring	Low	Moderate
Sinking	Medium	Moderate

19.5 Avoidance, Mitigation and Management Measures

This section describes avoidance, mitigation or management measures to reduce significance of impacts to the existing marine and estuarine ecological values. Arrow Energy will develop a construction management plan, which contains specific mitigation measures, performance indicators and management actions required to reduce impacts to the marine and estuarine ecological values. [C19.01]

19.5.1 Loss of Habitat

The engineering design process has sought to avoid impacts where feasible. Where impacts are unavoidable, mitigation and management measures are identified to reduce the significance of each impact to the maximum extent practicable. Where environmentally sensitive areas are significantly impacted by the project, and mitigation and management measures provide minimal recovery, offset strategies will compensate for the loss. The assessment of significance for residual impacts is then applied, assuming all avoidance and mitigation measures are successful.

Arrow Energy will establish a marine offsets strategy for the project to compensate for the loss of marine and estuarine habitat as a result of the project. [C19.02] Offsets developed under the strategy will follow the principles outlined under the Commonwealth offsets policy (DEWR, 2007) and may include:

- Rehabilitation of ‘like-for-like’ habitats that demonstrate ecological equivalence in the Gladstone region.
- Creation of artificial habitats that provide as-similar-as-possible ecological functions as the area that is to be lost in the Gladstone region.
- Facilitate, or otherwise manage under agreement, unprotected habitat and actively manage and protect the habitat as a conservation area. The habitat must demonstrate ecological equivalence to the area that is to be lost. Habitat should be purchased in the Gladstone region if possible; however, if this is not feasible, greater conservation value may come from locating offsets elsewhere.

Arrow Energy will comply with environmental and legal criteria of the Queensland Government environmental offsets policy as the overarching framework for a specific-issue offset policy (see Fish Habitat Management Operational Policy (Dixon & Beumer, 2002)). [C19.03] The policy follows similar principles to the Commonwealth policy and provides specific information on fish habitat areas.

Locations for offsets have not yet been identified and will require further assessment based on environmental suitability for ecological equivalence, feasibility and stakeholder engagement responses. The specific details of the offsets for the project will be provided in the marine offsets strategy.

Other mitigation measures may also assist in reducing the impact associated with the loss of marine and estuarine habitat, particularly those located in subtidal areas (including mangroves, saltmarsh and seagrass). These measures include:

- Keeping activities within the designated boundaries of work sites and identifying designated access tracks for the movement of equipment and personnel.
- Developing and implementing a rehabilitation management plan for intertidal areas that are used temporarily during construction activities.

19.5.2 Impact on Marine Fauna

Mitigation measures to reduce the impacts on marine fauna from boat strike, underwater noise (from pile driving and dredging and vessel noise), lighting and dredging are described below.

Boat Strike

Reduced speed and vigilance are the most effective mitigation against boat strike. Additional measures such as propeller guards, propulsion systems and hull design can reduce the severity of injury from accidental collision. These measures will only be effective if they are implemented as part of an overall management strategy for the Port of Gladstone. The proposed mitigation measures reflect the necessity for a holistic approach to mitigating the risk to marine fauna posed by boat strike.

- Contribute to the development of a Port of Gladstone shipping activity strategy and management plan. Comply with applicable speed limits for the Port of Gladstone-Rodds Bay Zone B dugong protection area, as detailed in the management plan. [C19.04]
- Install (where feasible) propeller guards (or equivalent) on high-speed vessels to reduce the impact of injury in the event of boat strike. [C19.05]

Underwater Noise

Much of the pile driving required for construction of marine infrastructure will be in intertidal and shallow subtidal areas, which will reduce the extent of transfer of underwater sound into deeper waters. The following measures will be implemented to reduce the impacts from underwater noise from pile driving and dredging activities:

- Implement soft start procedures where a sequential build-up of warning pulses will be carried out prior to commencement of full-power, pile-driving activities. [C19.06]
- Undertake fauna observations prior to and during pile-driving and dredging activities to check for the presence of marine turtles, dugongs and cetaceans. Should fauna be spotted within the area of the works, implement procedures to minimise impact, such as reverting to soft-start piling or stopping temporarily to allow animals to move away from the area. [C19.07]

Levels of underwater noise from project-related vessels are not easily mitigated and are not expected to be different from existing shipping activities in terms of sound frequency and intensity. Large LNG carriers are likely to be audible many kilometres away, particularly in the open ocean. Such vessels are detectable and avoidable by marine mammals before any physical injury from

sound occurs. Impacts are localised and will not reduce the extent of marine and estuarine communities or cause disturbance threatening their survival.

Lighting

Mitigation measures that will be implemented to reduce the impacts of lighting from the LNG plant and ancillary infrastructure include:

- Shield/direct the light source onto work areas where practical. [C17.16]
- Use long-wavelength lights, where practical, including use of red, orange or yellow lights. [C17.17]
- Lower the height of the light sources as far as practical. [C17.18]
- Avoid routine planned maintenance flaring at night during sensitive turtle reproductive periods (where practical). [C17.19]

Site lighting is also addressed in Chapter 17, Terrestrial Ecology, and Chapter 23, Landscape and Visual.

Dredging

Arrow Energy will develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g. current WBDD Project data) and will include [C15.02]:

- Requirements for monitoring of water quality. [C15.03]
- Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. [15.04]
- Keep within the identified dredge footprint area. [C19.08]
- Maintain a fauna spotting function (where possible). Dredging will not commence if marine mammals, turtles or crocodiles are spotted within the area of dredging, and will stop temporarily if fauna is spotted within the area of the dredge head. In both cases, resumption of dredging must wait until fauna has moved away. [C19.09]

19.5.3 Impact on Recreational and Commercial Fishing Access

Measures to address the impact on recreational and commercial fishing access are discussed in Chapter 4, Consultation and Communication, and Chapter 26, Social.

19.5.4 Introduced Species

Project vessels servicing the LNG plant that originate from overseas ports will comply with Commonwealth and local government ballast water management systems and implement Australian Quarantine and Inspection Service hull hygiene measures. [C19.10]

With the implementation of such measures, introduced species and pest species are considered to be a negligible impact and are unlikely to invade or establish a population in Port Curtis, the GBRMP, the GBRWHA or surrounding waters.

19.5.5 Shipping Activities and Accidents

All project vessels must comply with all applicable maritime law, especially when passing through the GBRMP. Project vessels will traverse the marine park via designated navigation routes with pilotage as required within port boundaries. [C19.11]

Further avoidance, mitigation and management methods applying to shipping activities are discussed in Chapter 28, Traffic and Transport.

19.6 Residual Impacts

Some residual impacts remain, assuming successful implementation of the identified mitigation measures. The residual effects of these impacts are described below, and the significance of the impacts are summarised in Table 19.10.

19.6.1 Loss of Habitat

Some loss of marine and estuarine habitat is unavoidable during construction in small areas where habitat is replaced by infrastructure. Mitigation measures are aimed at reducing this loss. Other areas may be affected directly and indirectly by dredging activities and the resulting increases in turbidity. The offsets strategy will aim to compensate for the loss of habitat as a result of the project. The magnitude of the impact will be reduced from low to very low as ecological equivalence will have been met, therefore lowering the significance of the residual impact from **minor** to **negligible**.

19.6.2 Impact on Marine Fauna

Boat strike, underwater noise and project lighting residual impacts are discussed below.

Boat Strike

Adherence to speed limits and remaining alert to the presence of dugong, marine turtles and cetaceans will contribute to reducing the potential for boat strike. Additional measures such as propeller guards might reduce the potential for fatalities.

Uncertainty about any speed limits that might be enforced and the implementation of additional measures, combined with the constraints on observation posed by turbidity and sea conditions, results in the potential for boat strike and fatalities (magnitude of impact) remaining high. The significance of the residual impact of boat strike is consequently **moderate**.

Underwater Noise

Measures to mitigate underwater noise from pile driving will reduce the magnitude of the impact from high to medium and the significance, in most cases, from moderate to **insignificant** or **minor**. The exceptions are the green and loggerhead turtles, which will still experience a moderate impact given the species' conservation status. The magnitude of impact from shipping and dredging is assessed as low and the significance of residual impacts is reduced to **minor**.

Lighting

The magnitude of the impact from any residual glow at Southend (approximately 8 km from the light source) will be very low with the implementation of the mitigation measures described above. The residual effect of lighting is assessed as **negligible**.

Restricting flaring (e.g., outside of nesting or hatching periods) may not be feasible given that certain processes are required for the operation and maintenance of the LNG plant. The magnitude of the impacts of flaring to the breeding of the turtle population at Southend will be low. Assuming all other mitigation measures are implemented, the residual effect of lighting on marine turtles will be **minor**.

19.6.3 Introduced Species

Trends in species introductions in the region and the protocols currently in place (e.g., MARPOL, Commonwealth and local government mandatory guidelines and antifouling measures) to prevent introductions, mean the residual impact of exotic species invasion into Port Curtis, the GBRMP and the GBRWHA, will be reduced to **negligible**.

19.6.4 Shipping Accidents

The residual impact assessment on shipping accidents addresses the direct impacts to the marine and estuarine environmental values in the event that an incident occurs. The assessment of likelihood of these incidents is discussed in Chapter 28, Traffic and Transport, and Chapter 29, Hazard and Risk.

While unlikely to occur, shipping accidents in Port Curtis, the GBRMP, the GBRWHA and surrounding waters will have a **moderate** to **major** significance and, should they occur, could cause widespread, severe and long lasting impacts on marine environmental values.

All project vessels servicing the LNG plant will comply with all international, Commonwealth and state government legislation and regulations. The magnitude of some impacts, should they occur, will still be high. When considered with the sensitivity of Port Curtis, the GBRMP, the GBRWHA and surrounding waters, the residual impact of shipping activities and accidents is **moderate** to **major**.

19.6.5 Summary of Residual Effects

Table 19.10 summarises the significance of the residual effects on marine and estuarine ecology values impacted by the project.

Table 19.10 Significance of impacts on marine and estuarine ecology values for the Arrow LNG Plant

Value	Sensitivity	Impact	Magnitude	Significance	Mitigation	Residual Magnitude	Residual Significance
Mangrove	Medium	Direct: loss and disturbance of marine and estuarine habitat (clearing).	Low	Minor	Develop and implement offset strategy.	Very low	Negligible
		Indirect: turbidity plumes from dredging.	Low	Minor	Develop and implement dredge management plan.	Very low	Negligible
Saltmarsh	Medium	Direct: loss and disturbance of marine and estuarine habitat (clearing).	Medium	Minor	Develop and implement offset strategy.	Very low	Negligible
Seagrass	High	Direct: loss and disturbance of marine and estuarine habitat (clearing).	Very low	Negligible	Not applicable.	Very low	Negligible
		Indirect: turbidity and sedimentation from dredging.	Low	Minor	Develop and implement dredge management plan.	Low	Minor
Benthic zone and intertidal mudflat	High	Direct: loss and disturbance of marine and estuarine habitat (clearing or dredging).	Low	Minor	Develop and implement offset strategy.	Low	Minor
		Indirect: turbidity and sedimentation from dredging.	Medium	Moderate	Develop and implement dredge management plan.	Very low	Negligible
Reef and rock substrate	Medium	Direct: loss and disturbance of marine and estuarine habitat (clearing or dredging).	Low	Minor	Develop and implement offset strategy.	Very low	Negligible
		Indirect: turbidity and sedimentation from dredging.	Low	Minor	Develop and implement dredge management plan.	Very low	Negligible
Dugongs	Medium	Direct: boat strike.	High	Moderate	Consider speed limits. Consider installing propeller guards.	High	Moderate

Table 19.10 Significance of impacts on marine and estuarine ecology values for the Arrow LNG Plant (cont'd)

Value	Sensitivity	Impact	Magnitude	Significance	Mitigation	Residual Magnitude	Residual Significance
Dugongs (cont'd)		Direct: underwater noise (pile driving).	High	Moderate	Implement fauna spotting procedure. Develop procedures to reduce impacts when fauna is within the area.	Medium	Minor
		Direct: underwater noise (dredging).	Medium	Minor	Keep within dredging footprint. Implement fauna-spotting procedure. Develop and implement dredge management plan.	Low	Minor
		Direct: underwater noise (shipping).	Medium	Minor	No practical ways to reduce the noise characteristics.	Low	Minor
Marine turtles (species dependent) Flatback Green Leatherback	 Medium High High	Direct: boat strike.	High	Moderate	Consider speed limits. Consider installing propeller guards.	High	Moderate
		Direct: underwater noise (pile driving).	High	Moderate	Implement fauna spotting procedure. Develop procedures to reduce impacts when fauna is within the area. Soft start.	Medium	Moderate
		Direct: underwater noise (dredging).	Medium	Moderate/ minor	Keep within dredging footprint. Implement fauna spotting procedure. Develop procedures to reduce impacts when fauna is within the area. Develop and implement dredge management plan.	Low	Minor

Table 19.10 Significance of impacts on marine and estuarine ecology values for the Arrow LNG Plant (cont'd)

Value	Sensitivity	Impact	Magnitude	Significance	Mitigation	Residual Magnitude	Residual Significance
Marine turtles (species dependent) (cont'd)		Direct: underwater noise (shipping).	Medium	Moderate/ minor	No practical ways to reduce the noise characteristics.	Low	Minor
		Direct: lighting.	Medium	Moderate/ minor	Shielding/direction of lighting Long-wavelength lights. Reduced height of lights. Scheduled maintenance flaring (where practical).	Low	Minor
Cetaceans	Medium	Direct: boat strike.	High	Moderate	Consider speed limits. Consider installing propeller guards.	High	Moderate
		Direct: underwater noise (shipping).	Medium	Minor	No practical ways to reduce the noise characteristics.	Low	Minor
Invertebrates/ macrobenthos	Low	Direct: underwater noise (pile driving).	High	Minor	As for other fauna.	Medium	Negligible
Plankton	Very low	Direct: underwater noise (pile driving).	High	Negligible	As for other fauna.	Medium	Negligible
Fish and shellfish	Medium	Direct: underwater noise (pile driving).	High	Moderate	Observation of the area. Soft start.	Medium	Minor
GBRWHA	Very high	Direct: introduced species and pest species.	Low	Minor	Company protocols; AQIS requirements for ballast, hull hygiene.	Very Low	Negligible

Note: For summary of impacts on commercial and recreational fishing access, refer to Chapter 26, Social.

19.7 Inspection and Monitoring

Management plans will be completed prior to construction and operation of the project. These plans will outline specific management and mitigation measures to reduce of impacts onto the marine and estuarine environmental values. These include:

- A construction management plan.
- A marine offsets management strategy.
- A rehabilitation management plan.
- A dredge management plan.
- A shipping activity management plan.

These management plans will also include inspection and monitoring measures required for the project. Specific measures are outlined in Table 19.11.

Table 19.11 Inspection and monitoring for impacted environmental values

Environmental Value Impacted	Objective	Mitigation	Inspection and Monitoring
Unavoidable, direct loss of mangrove, seagrass or saltmarsh vegetation	Replacement of like habitat.	Offset strategy.	Periodic monitoring of outcome as required in the offset strategy.
Indirect loss of mangrove, seagrass or saltmarsh vegetation during construction	Minimise lateral extent of vegetation disturbance.	Keep activities within designated boundaries (e.g., access tracks for equipment/personnel). Rehabilitation.	Routine inspection and audit.
Impacts to listed fauna from boat strike	Reduce risks of collision.	Speed limits. Propeller guards/jet boat hulls. Observation procedures.	Adherence to company procedures. Records of observations.
Impacts to listed fauna from underwater noise during construction (especially pile driving)	Avoid or limit exposure of listed fauna to underwater noise levels that could cause physiological harm.	Observation of area prior to start up – allow any listed fauna to move away before start up. Low-energy start up, as practicable.	Records of observations.
Impacts to listed fauna (marine turtles) from project lighting	Avoid disturbance to turtle nesting at Southend.	Shielding, redirecting and lowering light (as practicable). Light filtering (as practicable). Motion detection lighting (where practicable). Avoid maintenance flaring at night.	Contribution to existing long-term monitoring of turtle nesting (and additional monitoring where required). Contribution to Port Curtis-wide monitoring of seagrass habitats (e.g., Port Curtis Integrated Monitoring Program (PCIMP)).
Impacts to water quality from dredging.	Meet required water quality standards.	Dredge management plan for typical controls such as managing overflows. Keep within dredge footprint. Fauna observation function.	Inclusion of statutory water quality monitoring of turbidity thresholds in dredge management plan. Contribution to Port Curtis-wide monitoring of seagrass habitats (e.g., PCIMP).

Table 19.11 Inspection and monitoring for impacted environmental values (cont'd)

Environmental Value Impacted	Objective	Mitigation	Inspection and Monitoring
Impacts to marine ecosystems from introductions of pest species.	Avoid pathways for marine pest introduction.	Adherence to quarantine protocols for ballast exchange and anti-fouling protocols.	Records of compliance.

19.8 Commitments

The measures (commitments) that Arrow Energy will implement to manage impacts on marine and estuarine ecology are set out in Table 19.12.

Table 19.12 Commitments: Marine and estuarine ecology

No.	Commitment
C19.01	Develop a construction management plan will be completed, which contains specific mitigation measures, performance indicators and management actions required to reduce impacts to the marine and estuarine ecological values.
C19.02	Establish a marine offsets strategy for the project to compensate for the loss of marine and estuarine habitat as a result of the project.
	Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including:
C17.16	• Shield/direct the light source onto work areas where practical. Common with Chapter 17, Terrestrial Ecology, and Chapter 23, Landscape and Visual.
C17.17	• Use long-wavelength lights, where practical, including use of red, orange or yellow lights. Common with Chapter 17, Terrestrial Ecology.
C17.18	• Lower the height of the light sources as far as practical. Common with Chapter 17, Terrestrial Ecology.
C17.19	• Avoid routine planned maintenance flaring at night during sensitive turtle-reproductive periods (where practical). Common with Chapter 17, Terrestrial Ecology.
C15.02	Develop a dredge management plan that considers the appropriate water and sediment monitoring data (e.g. current WBDD Project data) and will include:
C15.03	• Requirements for monitoring of water quality.
C15.04	• Actions to be taken to minimise impacts of dredging on sensitive areas should water quality monitoring data show performance criteria are exceeded. Finalise specific actions in the dredge management plan. Common with Chapter 15, Coastal Processes, and Chapter 16, Marine Water Quality and Sediment.
C19.03	Comply with environmental and legal criteria of the Queensland Government environmental offsets policy as the overarching framework for a specific-issue offset policy.
C19.04	Contribute to the development of a Port of Gladstone shipping activity strategy and management plan. Comply with applicable speed limits for the Port of Gladstone-Rodds Bay Zone B dugong protection area, as detailed in the management plan.
C19.05	Install (where feasible) propeller guards (or equivalent) on high-speed vessels to reduce the impact of injury in the event of boat strike.
C19.06	Implement soft-start procedures where a sequential build-up of warning pulses will be carried out prior to commencement of full-power pile-driving activities.
C19.07	Undertake fauna observations prior to and during pile-driving and dredging activities to check for the presence of marine turtles, dugongs and cetaceans. Should fauna be spotted within the area of the works, implement procedures to minimise impact, such as reverting to soft-start piling or stopping temporarily to allow animals to move away from the area.

Table 19.12 Commitments: Marine and estuarine ecology (cont'd)

No.	Commitment
C19.08	Keep dredging activities within the identified dredge footprint area.
C19.09	Maintain a fauna-spotting function (where practical) during dredging activities. Do not commence dredging if marine mammals, turtles or crocodiles are spotted within the area of dredging, and stop temporarily if fauna is spotted within the area of the dredge head. In both cases, resumption of dredging must wait until fauna has moved away.
C19.10	Project vessels servicing the LNG plant that originate from overseas ports must comply with Commonwealth and local government ballast water management systems and implement Australian Quarantine and Inspection Service hull hygiene measures.
C19.11	All project vessels must comply with all applicable maritime law, especially when passing through the GBRMP. Project vessels will traverse the marine park via designated navigation routes with pilotage as required within port boundaries.